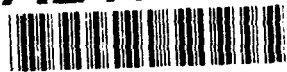


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JAN 29 1992

FINAL REPORT
SEPTEMBER 1989

REPORT NO. EVT 31-89

EVALUATION OF THE
RAILROAD BOXCAR LADING
STRAP ANCHORS ADAPTABLE TO
1 1/4-INCH STEEL BANDING

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U.S. Army Armament, Munitions
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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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<p>The U. S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), received comments from the Association of American Railroads/Bureau of Explosives(AAR/BOE) concerning typical anchor devices in steel boxcar sidewalls. Typical anchor devices will accommodate up to 1 1/4-inch steel banding. Using the bulkhead gate method of partial-layer bracing,USADACS performed the necessary rail impact tests to develop satisfactory railroad boxcar procedures using 1 1/4-inch bulkhead straps.</p> <p>Rail impact tests revealed a single layer, four pallet test load requires three 1 1/4-inch steel straps positioned across the face of the bulkhead for longitudinal restraint. Total weight of the four pallet test load is 6,890 pounds.</p>					
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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. EVT 31-89

EVALUATION OF THE RAILROAD BOXCAR LADING STRAP ANCHORS
ADAPTABLE TO 1 1/4-INCH STEEL BANDING

TABLE OF CONTENTS

PART	PAGE NO.
1. GENERAL.....	1-1
A. INTRODUCTION.....	1-1
B. AUTHORITY.....	1-1
C. OBJECTIVE.....	1-2
D. CONCLUSIONS.....	1-2
E. RECOMMENDATIONS.....	1-2
2. TEST ATTENDEES.....	2-1
3. TRANSPORTABILITY TESTING PROCEDURES.....	3-1
A. RAIL IMPACT TESTING.....	3-1
B. INSPECTIONS AND DATA COLLECTION.....	3-2
4. TEST SPECIMENS AND RESULTS.....	4-1



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A-1					

Part I

GENERAL

A. INTRODUCTION:

1. The U.S. Army Defense Ammunition Center and School(USADACS), Validation Engineering Division (SMCAC-DEV), was requested by the Association of American Railroads/Bureau of Explosives (AAR/BOE) to illustrate in USADACS 1948 Series Drawings the type of lading strap anchor found in the sidewall of a typical all-steel boxcar. The typical all-steel box is equipped with lading strap anchors that will accommodate 1 1/4-inch steel strapping rather than the 2-inch steel strapping currently illustrated in boxcar blocking and bracing procedures.

2. Using an all-steel anchor-equipped boxcar, RBOX 40247, USADACS performed several rail impact tests in accordance with the AAR/BOE standards using the bulkhead gate method of partial-layer bracing. A single layer, four pallet test load of 6,890 pounds was successfully rail impacted while being restrained with three 1 1/4-inch steel straps across the face of the bulkhead for longitudinal restraint.

B. AUTHORITY:

1. The test was accomplished in accordance with mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM). References are as follows:

(a) Change 4, 4 October 1974, to AR 740-1, 23 April 1973, Storage and Supply Activity Operation.

(b) AMCCOM-R 10-17, Mission and Major Functions of USADACS, 13 January 1986.

(c) Letter, AAR/BOE, 19 April 1989.

2. Per reference 1.B.1.c., their drawing approval process is discontinued pending illustration of the type of lading strap anchors found in typical all-steel type boxcar sidewalls. Rail impact testing is required to develop and evaluate a satisfactory boxcar procedure for AAR/BOE approval.

C. OBJECTIVE. The objective of this test was to develop and evaluate a boxcar loading and bracing procedure using lading strap anchors along with 1 1/4-inch steel strapping for the bulkhead gate method of partial-layer bracing.

D. CONCLUSIONS:

1. The one-layer load of six pallets, weighing a total of 10,330 pounds, could not be restrained with two, three, or four bands of 1 1/4-inch steel strapping during the 8 miles per hour (mph) rail impact.

2. The one-layer load of four pallets, weighing a total of 6,890 pounds, was successfully restrained with three bands of 1 1/4-inch steel strapping during the 8 mph rail impact.

3. The lading strap anchor device in the sidewall of the railroad boxcar was located a distance of 33 inches from the opposite-the-load side of the bulkhead gate when using the one layer load of four pallets.

E. RECOMMENDATIONS:

1. Recommend that a bulkhead gate used in combination with three bands of 1 1/4-inch steel strapping not retain more than 7,000 pounds of load in a railroad boxcar.

2. Recommend that a bulkhead gate used in combination with two bands of 1 1/4-inch steel strapping not retain more than 4,500 pounds of load in a railroad boxcar.

3. Recommend the AAR/BOE's required 36 inches from the lading strap anchor to the face of the load be reduced to 33 inches needed for the reduced load restrained by the 1 1/4-inch strapping.

PART 2

EVALUATION OF THE RAILROAD BOXCAR LADING STRAP ANCHORS
ADAPTABLE TO 1 1/4-INCH STEEL BANDING

SEPTEMBER 1989

TEST ATTENDEES

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PART 3

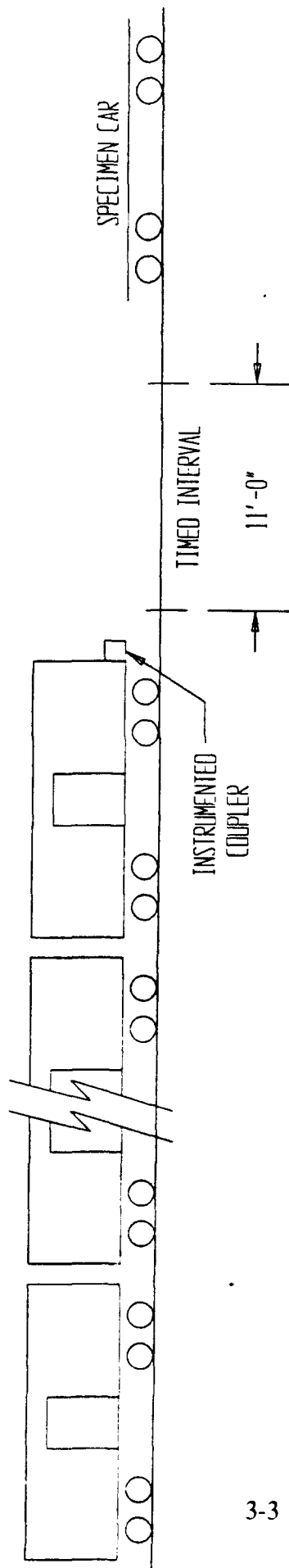
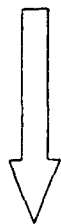
TRANSPORTABILITY TESTING PROCEDURES

A. RAIL IMPACT TESTING. Rail impact testing was accomplished in compliance with previously approved and standardized testing procedures (as shown on page 3-3) and described as follows:

1. The "specimen car" was scheduled to be impacted three times at speeds of 4, 6, and 8 mph in one direction. The 4 and 6 mph impact speeds are approximate; the 8 mph speed is a minimum. No reverse impact was performed as the load only occupied half of the railcar.
2. Impacting was accomplished by striking the test car (specimen car) into a line of five stationary cars (buffer cars). The buffer cars were coupled with all connecting draft gears compressed together to the extent possible under prevailing conditions, with all air brakes in a "set position."
3. A locomotive (switch engine) was utilized to start the "specimen car" rolling in the direction of the buffer cars along an approximate 300-foot segment of level trackage.
4. The "specimen car" was cut loose from the engine approximately 75-feet from the point of impact and allowed to run freely into the first of the buffer cars.
5. Impacting speeds were determined by the utilization of an electronic counter which measured the time required for the "specimen car" to traverse an 11-foot distance immediately prior to contact; recorded elapsed time was converted to mph speeds. Additional verification of impacting speeds was accomplished by utilization of an electronic stopclock.

B. INSPECTIONS AND DATA COLLECTION. At selected intervals during testing, thorough inspections of the specimen loads were made by technically proficient personnel to collect data on the specimen load and equipment resulting from load test steps. This data is recorded in part 4, following.

ASSOCIATION OF AMERICAN RAILROADS (AAR) STANDARD TEST PLAN



SPECIMEN CAR
IS RELEASED BY
SWITCH ENGINE TO
ATTAIN: IMPACT NO. 1 @ 4 MPH
IMPACT NO. 2 @ 6 MPH
IMPACT NO. 3 @ 8 MPH

5 BUFFER CARS (ANVIL) WITH DRAFT GEAR
COMPRESSED AND AIR BRAKES IN A SET
POSITION
ANVIL CAR TOTAL WT 250,000 LBS (APPROX)

FIGURE 1

PART 4

TEST SPECIMENS AND RESULTS

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 1:

The test load of six pallets of propelling charges, one layer high and two rows wide, weighing 10,330 pounds, was secured in the "A" end of boxcar RBOX 40247. The load was restrained by two 1 1/4-inch steel straps doubled across the face of the strapping bulkhead gate.

Each bulkhead steel strap consisted of two pieces. Each piece was threaded through the railroad boxcar strap anchor device, and the strap secured at the anchor point with a seal located 18 inches from the anchor device. The inside strap from each side was tensioned and sealed across the face of the bulkhead at both elevations before the second strap was tensioned and sealed. Tensioning the outer strap over the already sealed inner strap caused the inner strap to buckle and become slack.

In tensioning the steel strapping for this load, the strapping was drawn against the corner of the pallet. In this case, the banding pulled against the edge of the bell of the propelling charge container. The length of this bulkhead gate was constructed two inches less than the inside width of the boxcar. The length of the bulkhead gate should be constructed 1/2-inch less than the width of the boxcar to protect the strapping from cornering against the metal edge of the bell of the propelling charge container.

The rail impacts at 4 and 6 mph were uneventful. On the third rail impact at 8.33 mph, both steel straps failed at the crimp in the clip located near the strap anchor in the boxcar sidewall. The inner strap in each loop which was slack after tensioning, remained undamaged and in place.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 1:

DATE: 20 June 1989

TEST SPECIMEN: Six pallets of propellant charge containers in a single layer restrained by two 1 1/4-inch steel straps looped through the lading strap anchor.

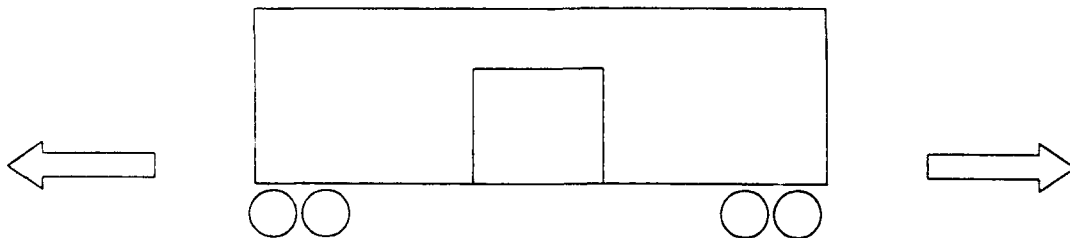
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

LADING & DUNNAGE WT. 10,330

TOTAL SPECIMEN WT. 73,430

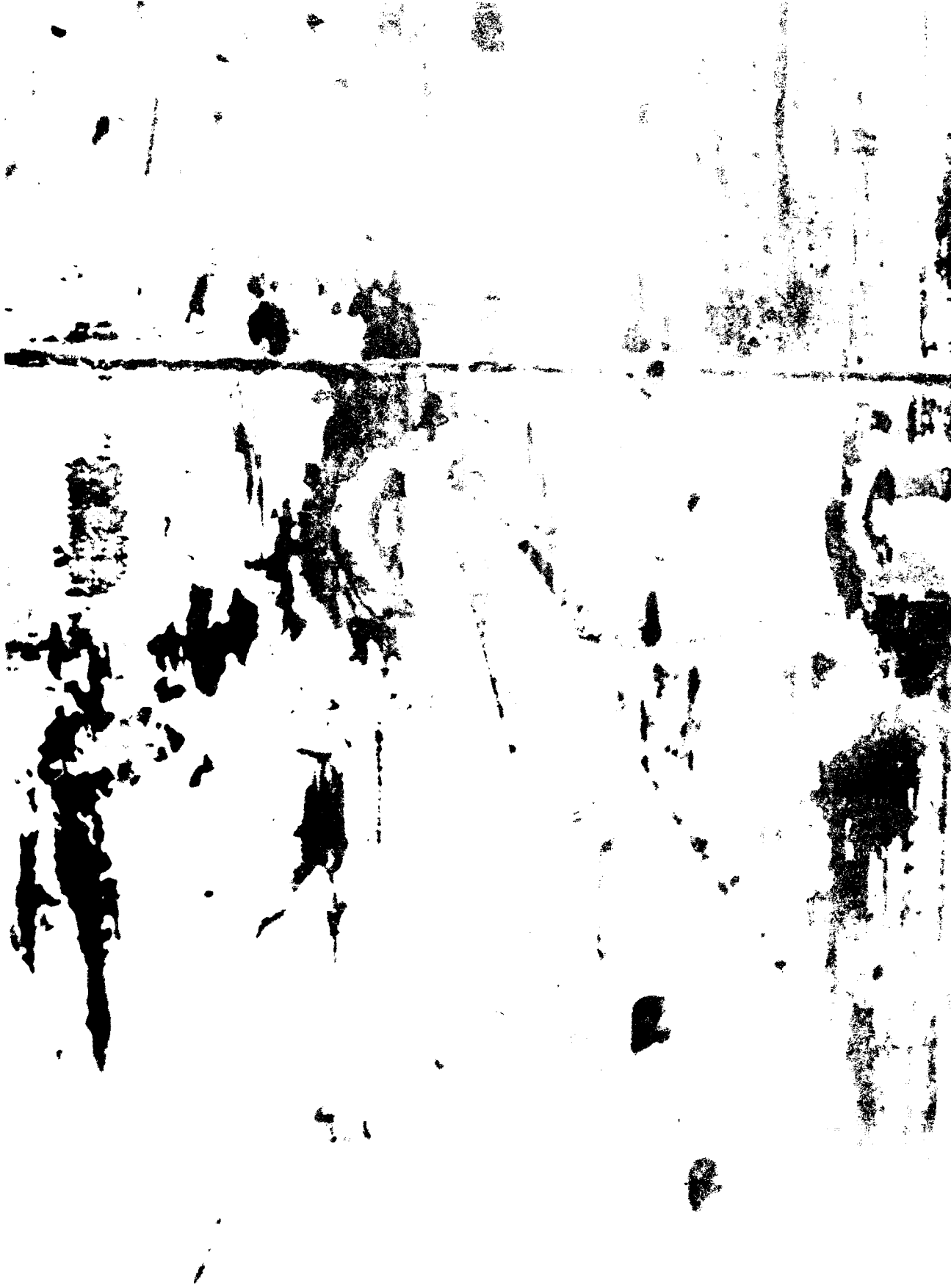
BUFFER CAR (5 CARS) WT. 250,000

IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.31	Strapping gate bowed 3/8-inch at center.
2	B	6.34	Strapping gate bowed an additional 3/8-inch at the center.
3	B	8.33	Top band broke at the crimp. Load moved rearward 12 1/4-inches. FAILURE.



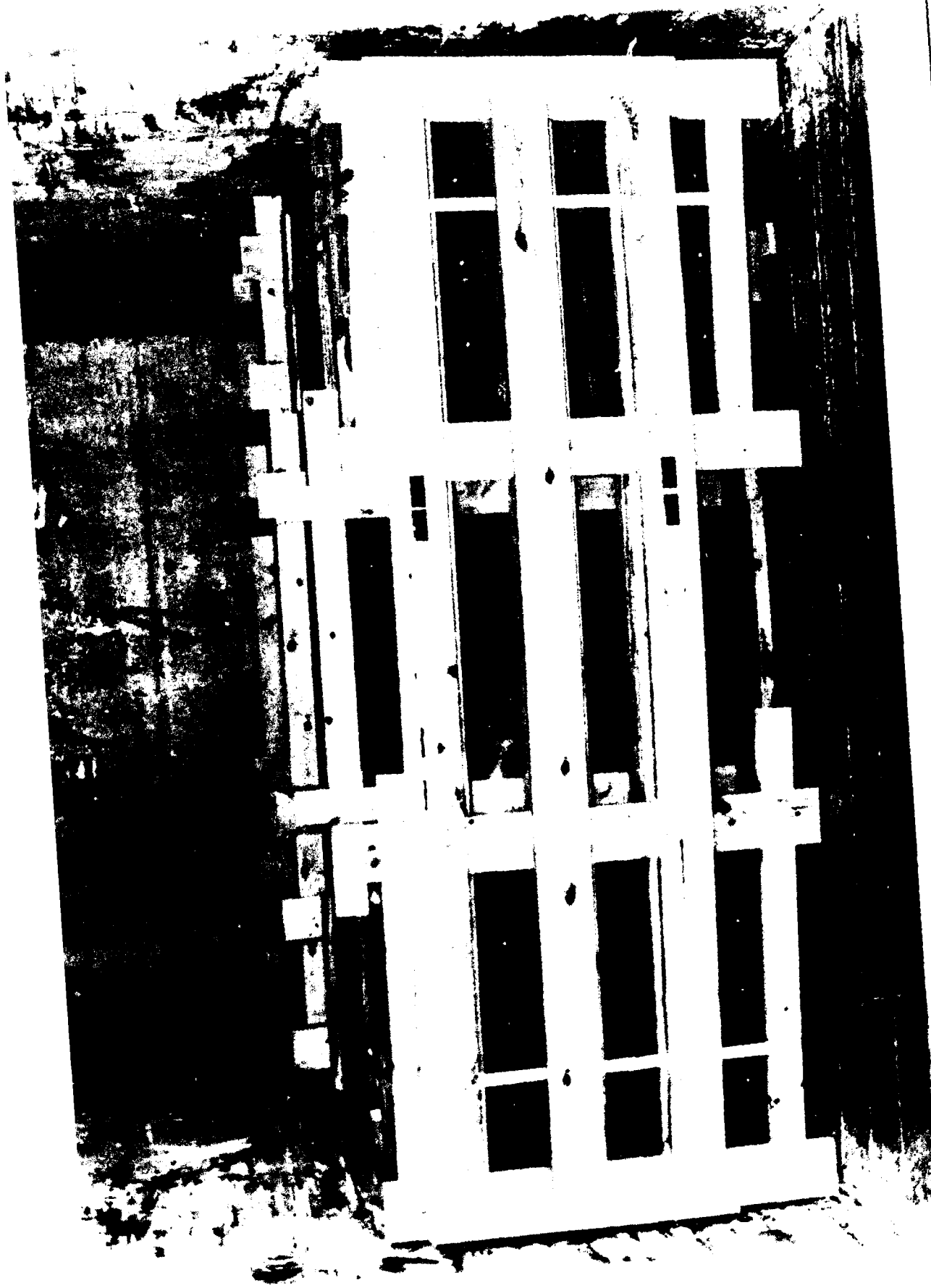


U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	Photo No. AO317-SPN-89-3771. View of the strap anchor device located in the sidewall of the railroad boxcar.
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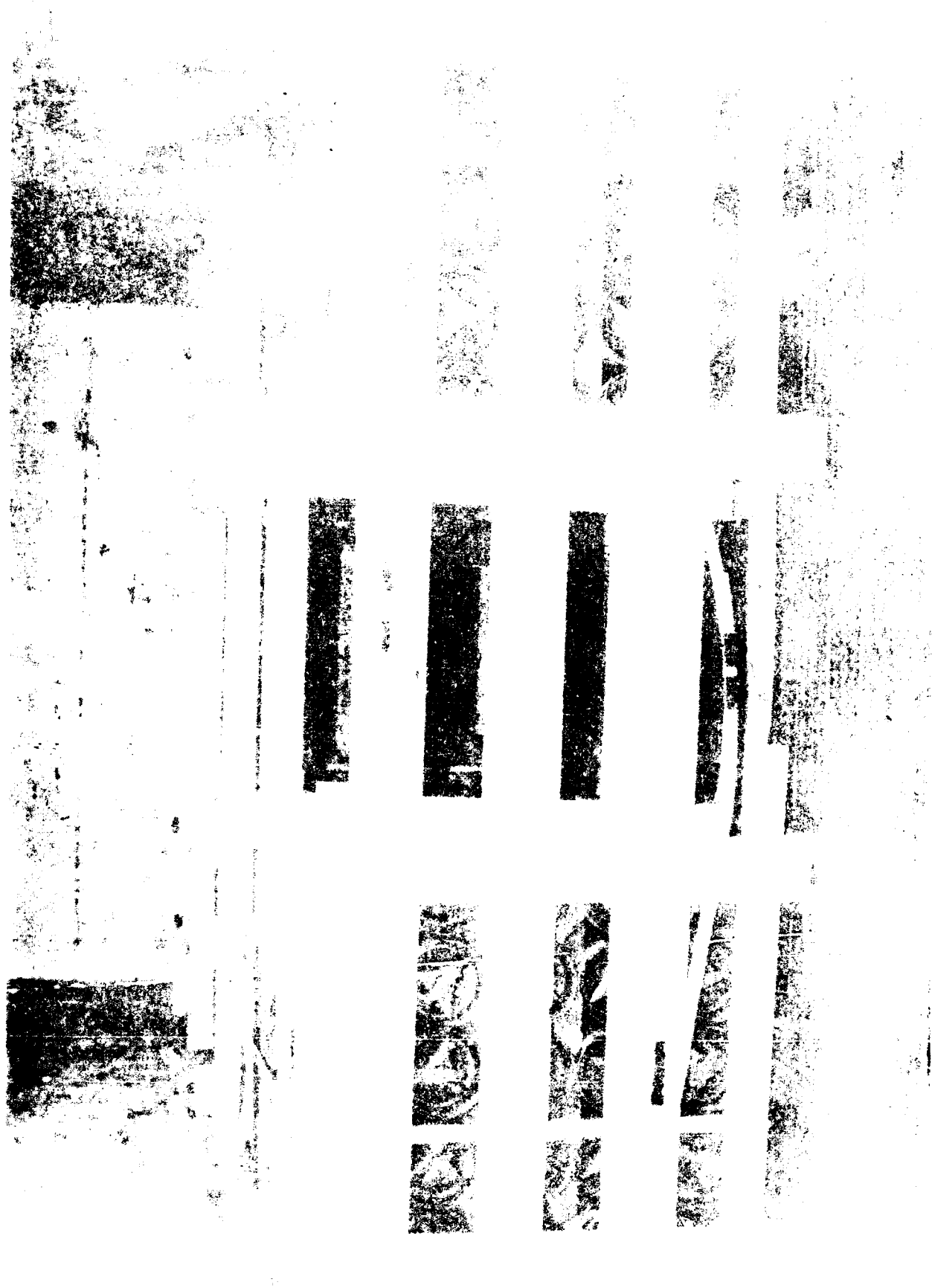
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-3776. View of a 1 1/4-inch steel strap threaded through the strap anchor device.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-962-4188. View of the two 1 1/4-inch steel straps across the strapping gate restraining the six pallets of propelling charges.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317 SPN-89-3769. View of the failure of both of the 1 1/4-inch steel straps following the 8 mph rail impact.

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 2:

The test load configuration of six pallets of propelling charges remained the same for this test. The load was restrained by two 1 1/4-inch steel straps doubled across the face of the strapping bulkhead gate.

The only change from Test No. 1 was the seal of the looped strap located 18 inches from the anchor device in the boxcar sidewall was not used. The intent in eliminating these seals was to permit the steel strap to feed or flow through the strap anchor device in the sidewall, equalizing the tension in each strap of the loop that extends across the face of the strapping bulkhead gate.

The 4 and 6 mph rail impacts were again uneventful. The third impact at 7.86 mph resulted in the upper steel strap failing at the crimp in the seal. The bottom strap loop did not fail, and both straps of the bottom loop remained in nearly equal tension.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 2:

DATE: 21 June 1989

TEST SPECIMEN: Same palletized load and banding made complete loop except the banding was not clipped and crimped at the lading strap anchor.

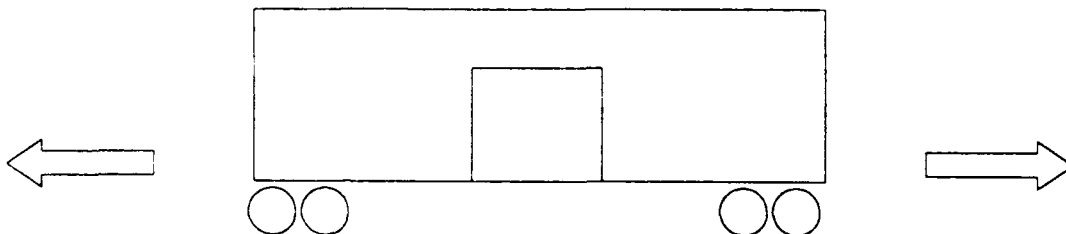
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

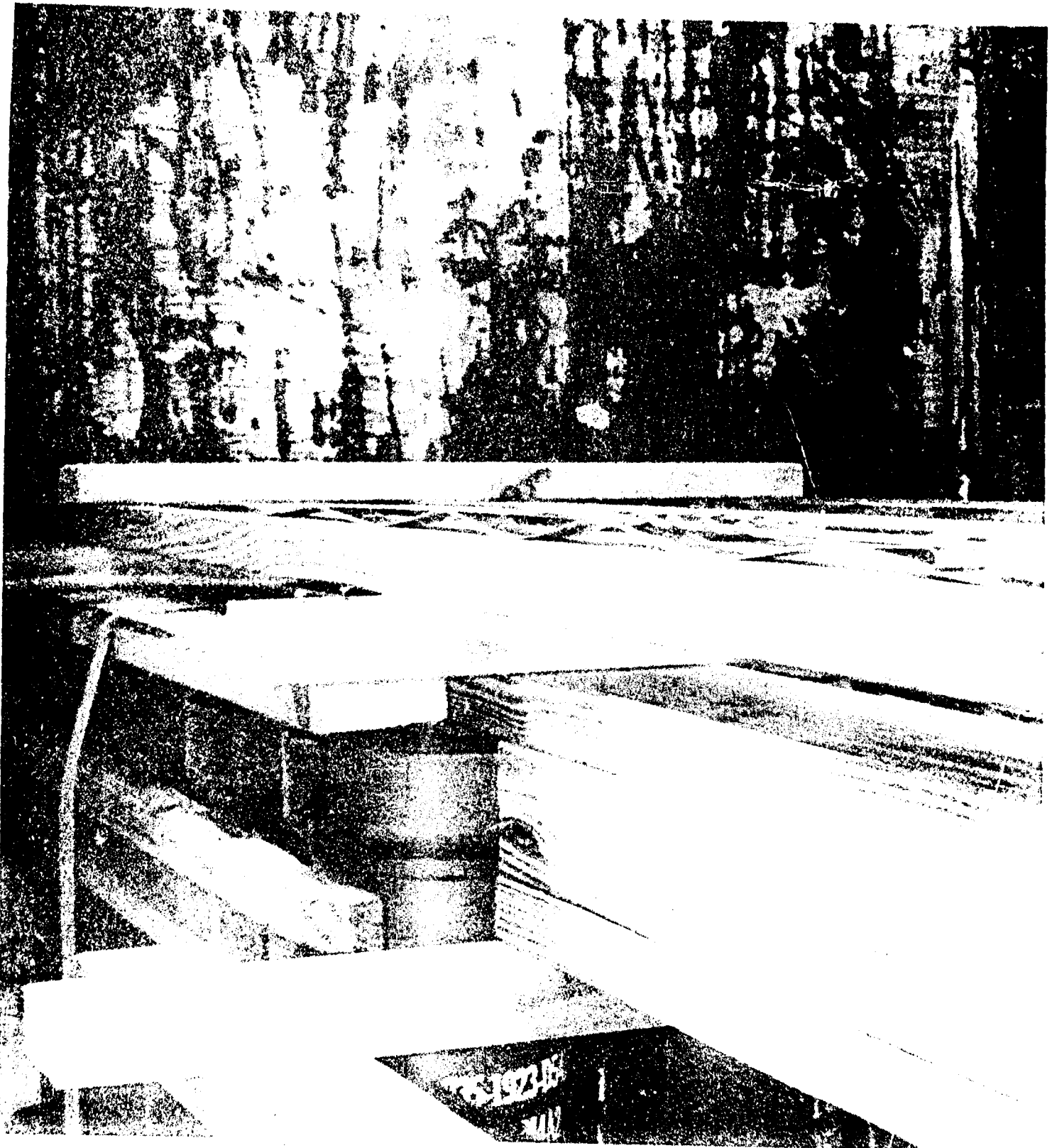
LADING & DUNNAGE WT. 10,330

TOTAL SPECIMEN WT. 73,430

BUFFER CAR (5 CARS) WT. 250,000

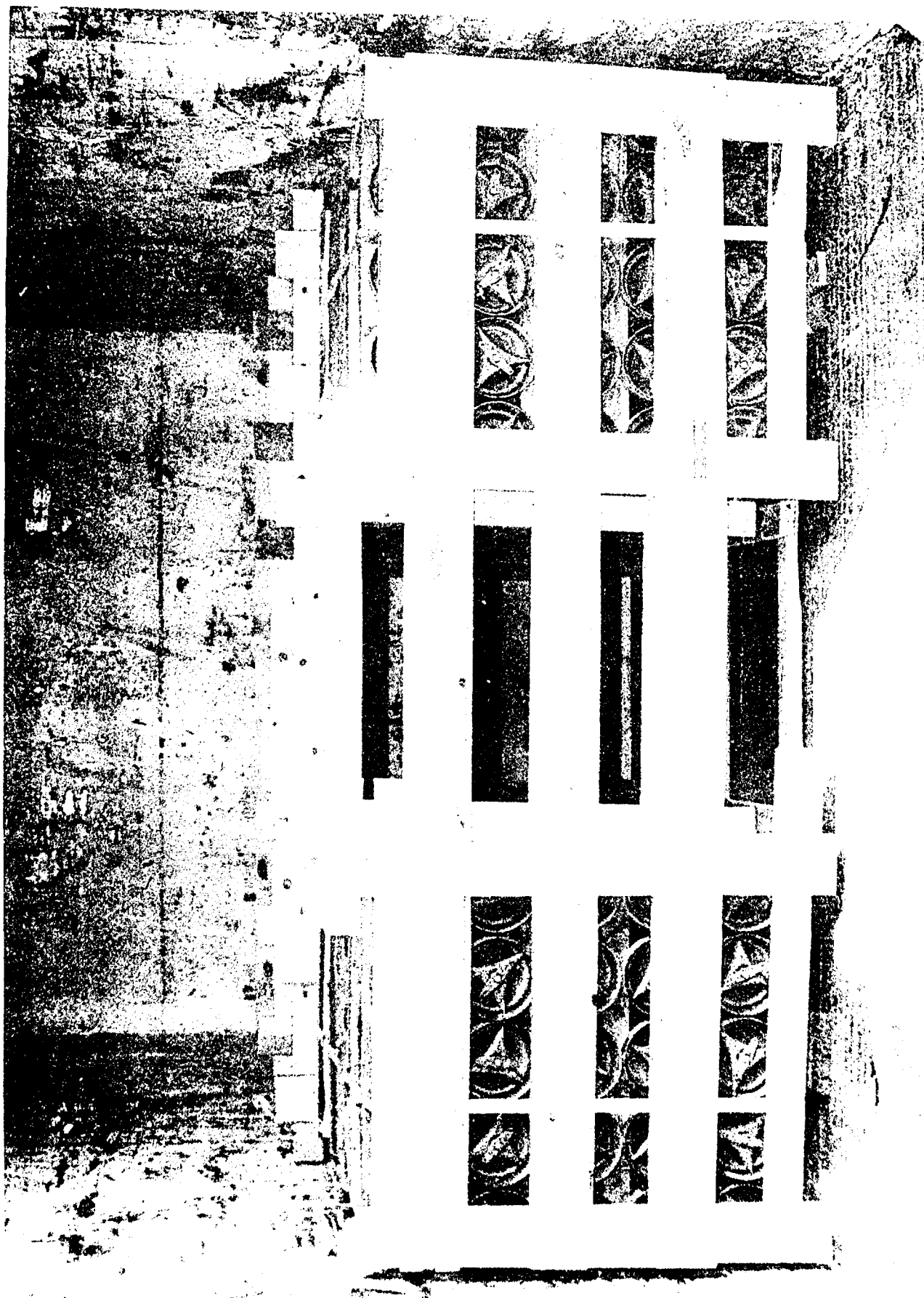
IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.39	Strapping gate bowed 5/16-inch at the center.
2	B	6.33	Strapping gate bowed an additional 1/8-inch at the center.
3	B	7.86	Top band broke at the crimp. Strapping gate center moved rearward an additional 3/8-inch and side moved rearward 3/4-inch. FAILURE.





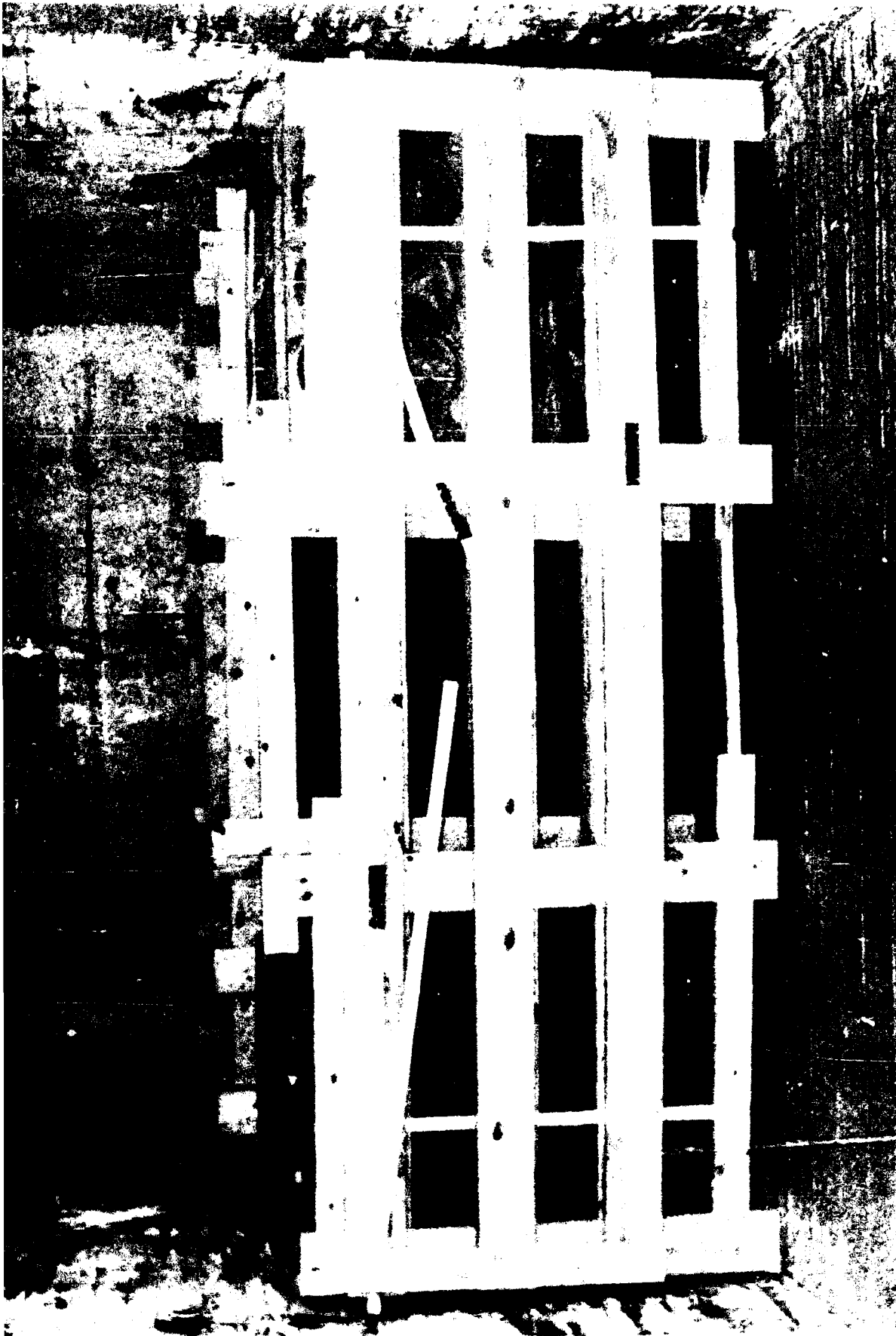
U.S. ARMY DEFENSE AMMUNITION CENTER AND
SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-3783. View of the top 1 1/4-inch steel strap showing how the inner strap of the loop was not taut and buckled when the outer strap of the loop was tensioned.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-3775. View of the 1 1/4-inch steel straps across the strapping gate restraining the six pallets of propelling charges.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-3781. View of the failed upper strap during the 8 mph rail impact.

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 3:

The test load configuration of six pallets of propelling charges remained the same for this test. The load was restrained by three 1 1/4-inch steel straps across the face of the strapping bulkhead gate.

Each bulkhead steel strap consisted of two pieces. Each piece was threaded through the railroad boxcar strap anchor device, and the strap was secured around the anchor point with a seal located 12 inches from the anchor device.

During the second rail impact at 6.24 mph, the lowest steel strap failed at the notch in both seals located adjacent to each strap anchor device in the boxcar sidewall. The upper two steel straps were not damaged.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 3:

DATE: 22 June 1989

TEST SPECIMEN: Same palletized load except three bands were used. The bands did not make a complete loop, but were clipped and crimped at the lading strap anchor in the boxcar sidewall.

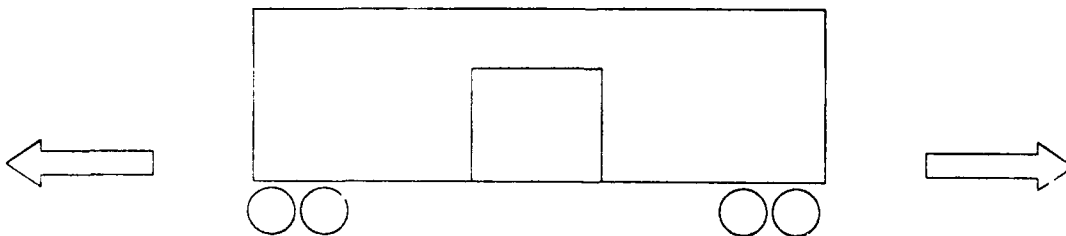
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

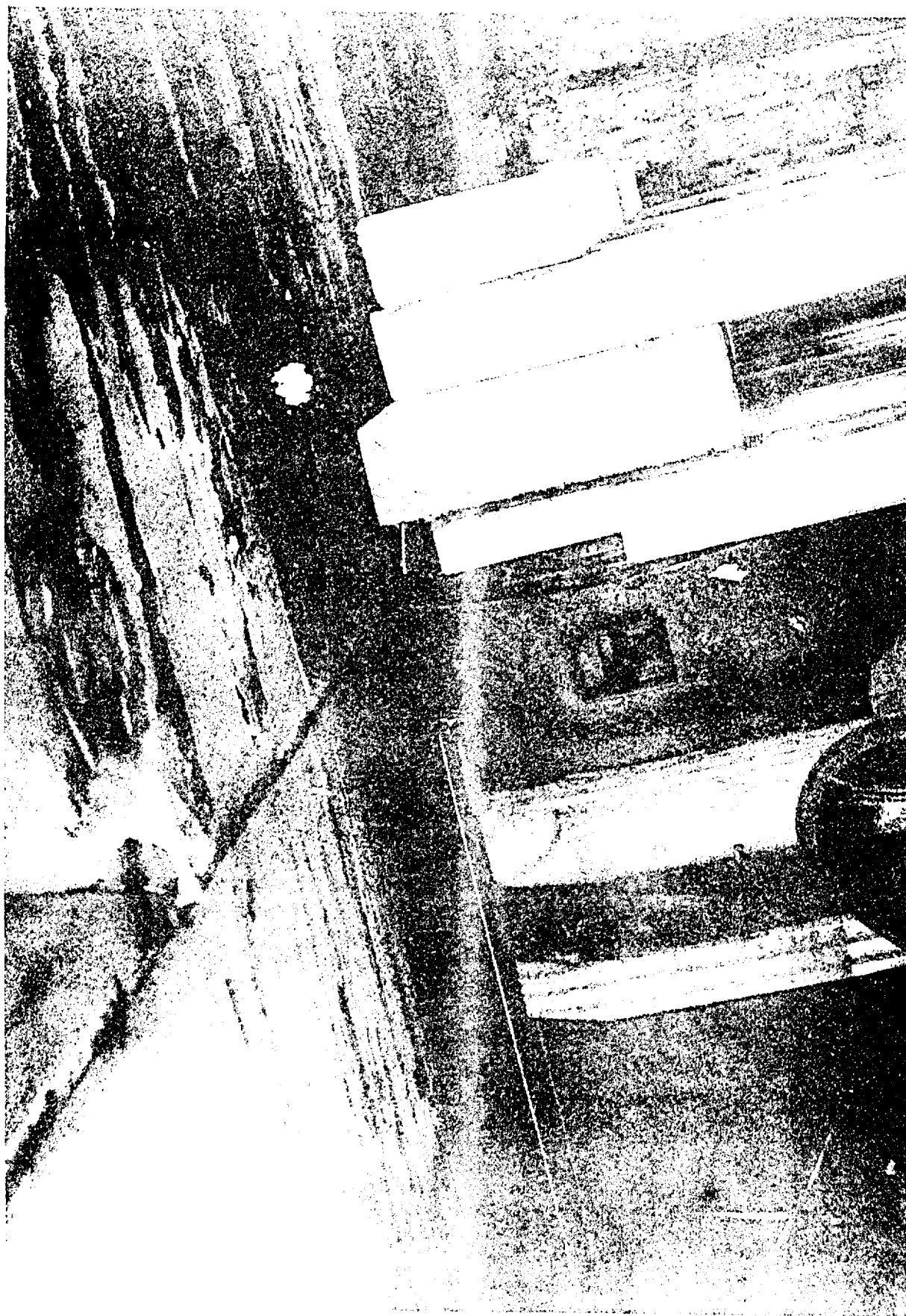
LADING & DUNNAGE WT. 10,330

TOTAL SPECIMEN WT. 73,430

BUFFER CAR (5 CARS) WT. 250,000

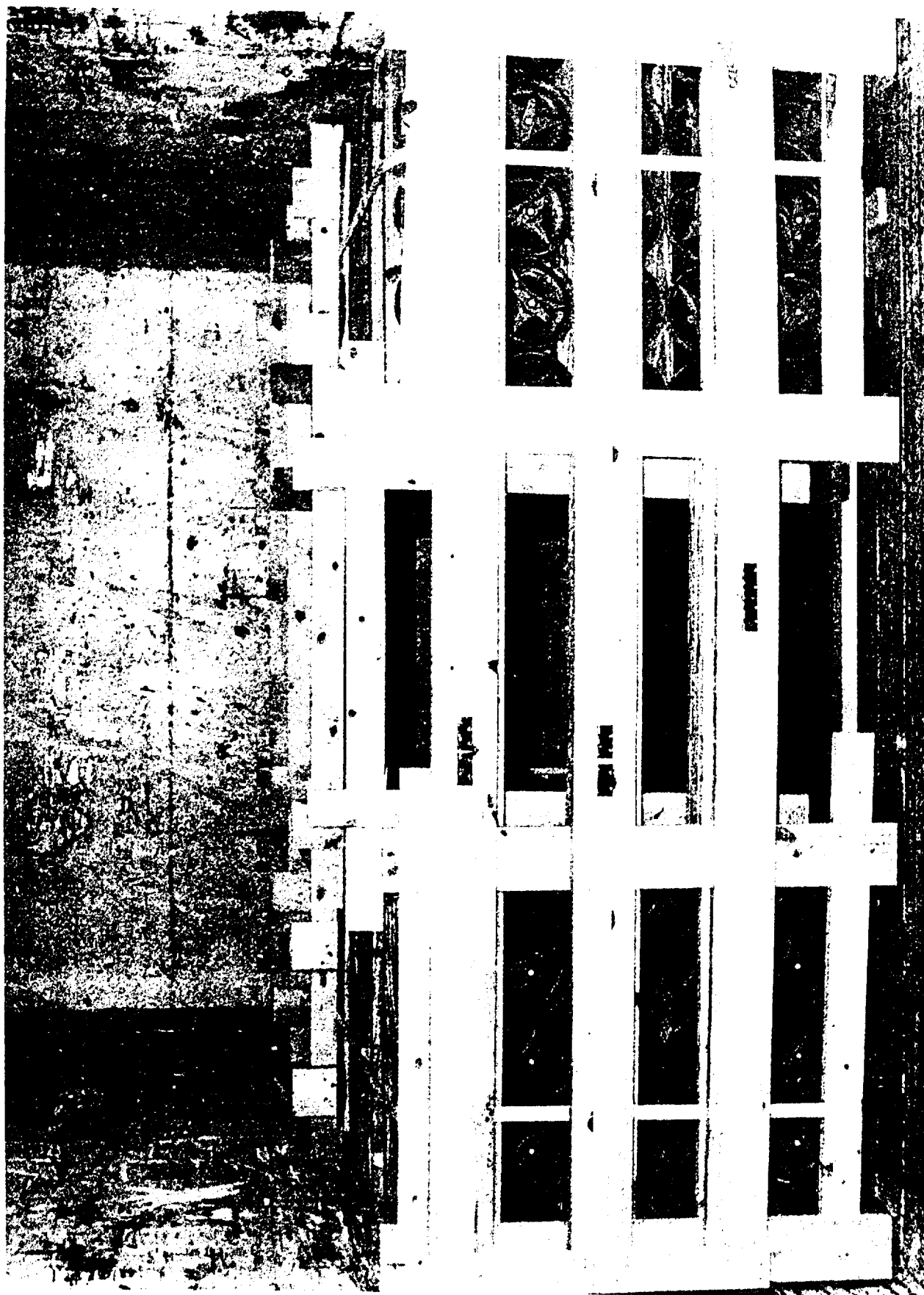
IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.29	Strapping gate bowed 1/4-inch at the center.
2	B	6.24	Bottom band failed at the crimp adjacent to both lading strap anchors on the boxcar sidewall. FAILURE.





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Photo No. AO317-SPN-89-3786. View of the single length of 1 1/4-inch steel strapping across the face of the strapping gate as banding was looped through the anchor and clipped. Note: Close proximity of steel strapping to the edge of the bell of the propelling charge container.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-3787. View of the three 1 1/4-inch steel straps across the strapping gate restraining the six pallets of propelling charges.

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 4:

The test load configuration of six pallets of propelling charges remained the same for this test. The load was restrained by four 1 1/4-inch steel straps across the face of the strapping bulkhead gate. The fourth steel strap was threaded through the railroad boxcar strap anchor device located nine inches above the boxcar floor and only 33 inches behind the face of the strapping bulkhead gate.

Each bulkhead steel strap consisted of two pieces. Each piece was threaded through the railroad boxcar strap anchor device, and the strap secured at the anchor point with a seal located 12 inches from the anchor device.

During the third rail impact at a speed of 8.08 mph, all four steel straps failed when the strap broke at the notch in the seal located 12 inches from the anchor device. The six pallets moved six inches forward, after the four steel straps separated.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 4:

DATE: 23 June 1989

TEST SPECIMEN: The same palletized load was used with a fourth band added 9 inches above the floor and attached to a lading strap anchor located 33 inches from the face of the banding gate.

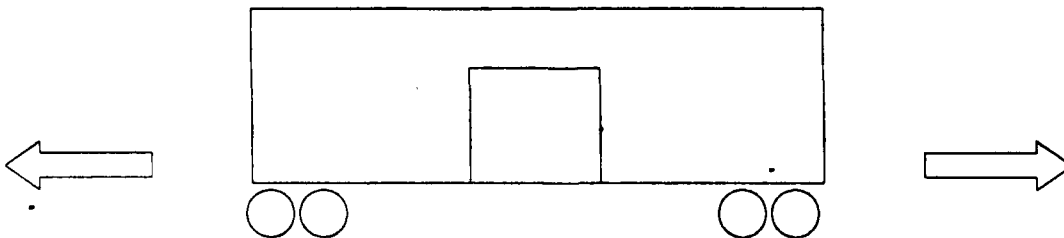
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

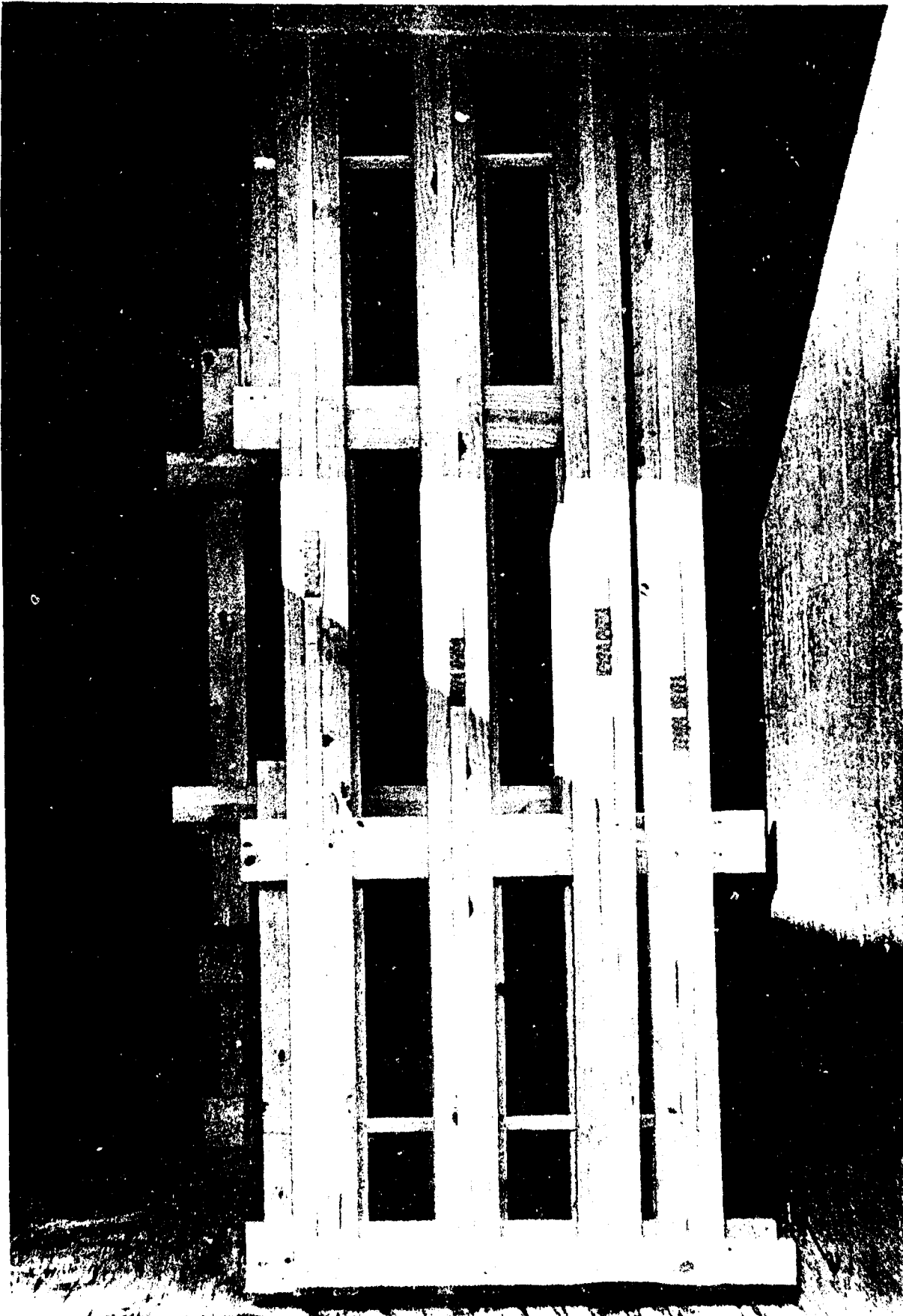
LADING & DUNNAGE WT. 10,330

TOTAL SPECIMEN WT. 73,430

BUFFER CAR (5 CARS) WT. 250,000

IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.07	Strapping gate bowed 1/4-inch at the center.
2	B	6.15	No movement.
3	B	8.08	Entire load moved rearward 11 inches. FAILURE.





	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL
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Photo No. AO317-SPN-89-3732. View of the four 1 1/4-inch steel straps across the strapping gate restraining the six pallets of propelling charges.

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 5:

The test load was reduced to four pallets of propelling charges, one layer high and two rows wide, weighing 6,890 pounds. The load was restrained by four 1 1/4-inch steel straps across the face of the strapping bulkhead gate.

Each bulkhead steel strap consisted of two pieces. Each piece was threaded through the railroad boxcar strap anchor device, and the strap secured at the anchor point with a seal located 12 inches from the anchor device. With reduction in load from six pallets to four pallets, the row of strap anchor devices on the railroad boxcar wall was located only 12 inches from the face of the face of the strapping bulkhead gate.

The rail impacts of 4,6, and 8 mph were performed with accumulated movement at the center of the strapping bulkhead gate of less than 1/2-inch. The four 1 1/4-inch steel straps restrained the 6,890-pound load.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 5:

DATE: 26 June 1989

TEST SPECIMEN: Four pallets of propellant charge containers in a single layer were tested instead of six pallets. Four bands were placed around the banding gate extending to a row of lading strap anchors located 12 inches in back of the face of the banding gate.

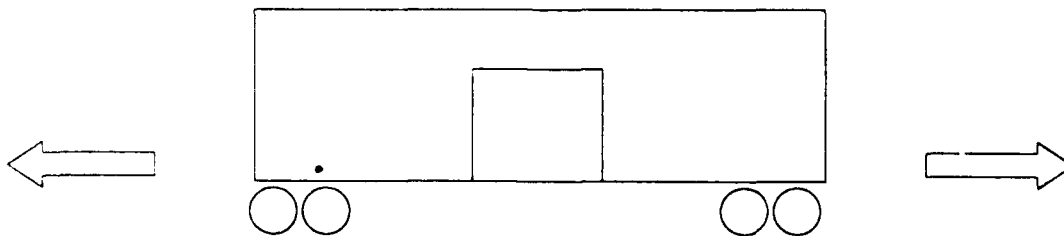
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

LADING & DUNNAGE WT. 6,890

TOTAL SPECIMEN WT. 69,990

BUFFER CAR (5 CARS) WT. 250,000

IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.18	No movement.
2	B	6.15	Strapping gate bowed 1/4-inch at the center.
3	B	8.43	Strapping gate bowed an additional 1/4-inch at the center. GOOD LOAD.





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Photo No. AO317-SPN-89-962-4193. View of the top two 1 1/4-inch steel straps of the four 1 1/4-inch straps used to restrain the four pallets of propelling charges.

SYNOPSIS OF RAIL IMPACT TEST

TEST NO. 6:

The load used in Test No. 5 was reused in this test except the bottom strap was cut leaving a total of three steel straps restraining the 6,890-pound load.

The rail impacts of 4, 6, and 8 mph were performed with accumulated movement at the center of the strapping bulkhead gate of less than 1/2-inch.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 6:

DATE: 26 June 1989

TEST SPECIMEN: Same four-pallet load as was used in Test No. 5, except the bottom band was removed leaving three bands around the strapping gate.

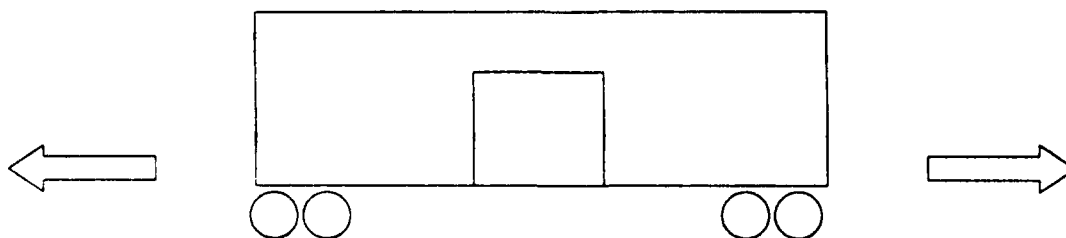
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

LADING & DUNNAGE WT. 6,890

TOTAL SPECIMEN WT. 69,990

BUFFER CAR (5 CARS) WT. 250,000

IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1	B	4.01	Strapping gate moved rearward 1/16-inch.
2	B	5.89	Gate moved forward 1/32-inch.
3	B	8.17	Strapping gate bowed 3/8-inch at the center. GOOD LOAD.



SYNOPSIS OF RAIL IMPACT TEST

TEST No. 7:

The load used in Tests Nos. 5 and 6 was reused in this test except the middle strap was cut leaving a total of two straps restraining the 6,890-pound load.

The load did not move during the 4.24 mph rail impact. The 6.10 mph rail impact resulted in the strapping gate rebounding 3/16-inch at the gate's center. The 8 mph rail impact was not measured, but it appeared to be close to the desired speed. Both remaining 1 1/4-inch steel straps failed through the crimp in the strap.

TEST SPECIMENS AND RESULTS

RAIL IMPACT TEST DATA

TEST NO. 7:

DATE: 26 June 1989

TEST SPECIMEN: Same four-pallet load used in Test No. 6, except the middle band was removed leaving two bands around the strapping gate.

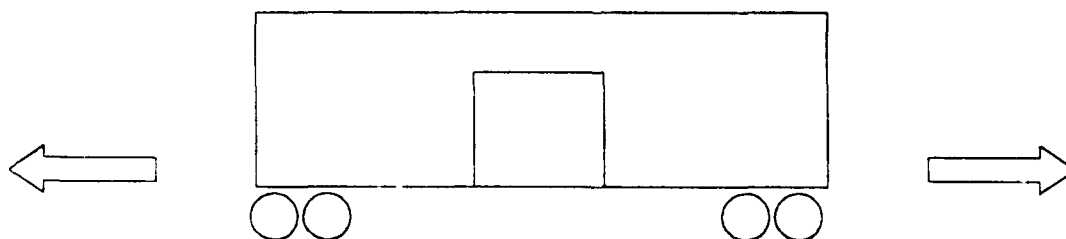
TEST BOXCAR NO. RBOX 40247 LT. WT. 63,100

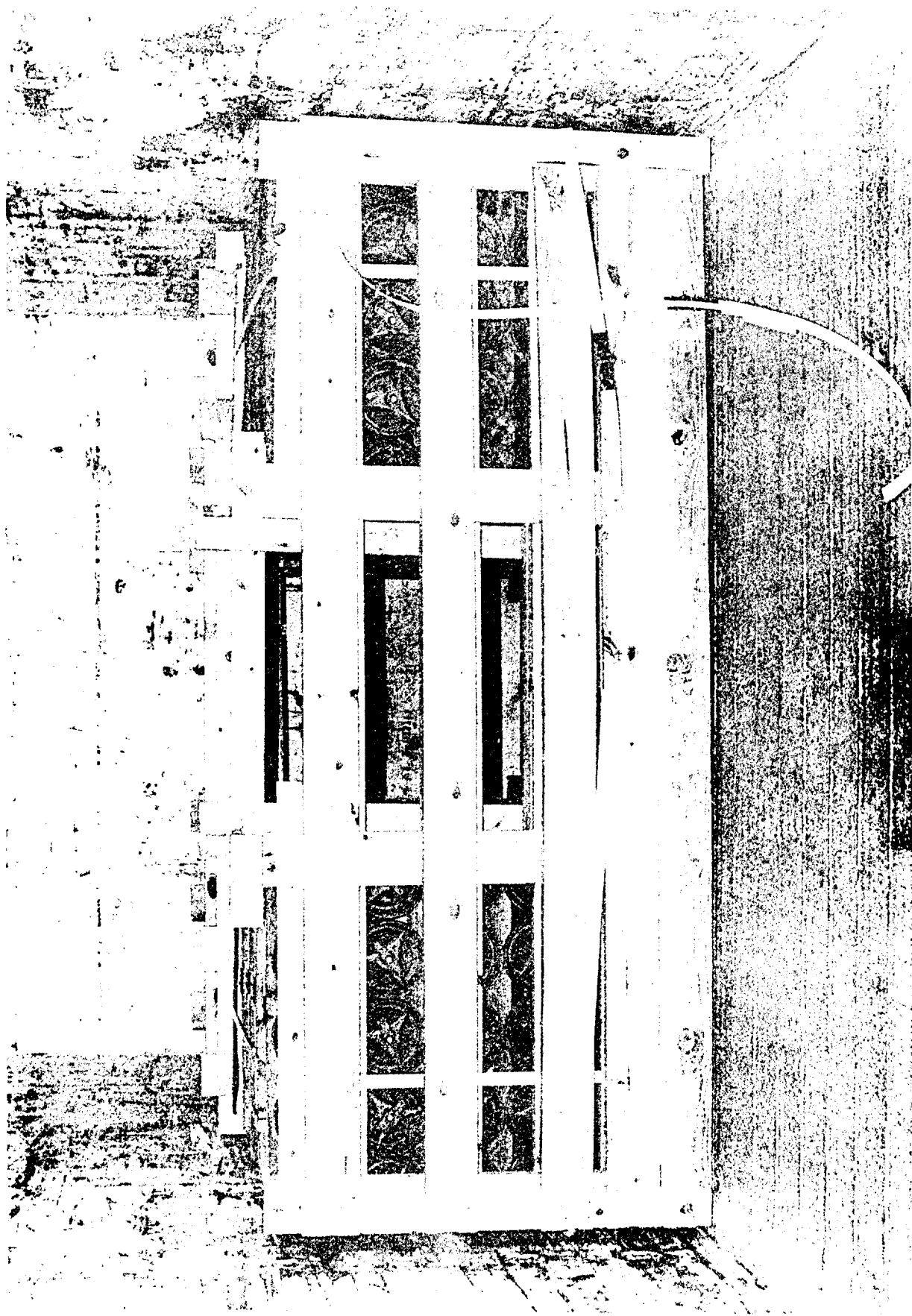
LADING & DUNNAGE WT. 6,890

TOTAL SPECIMEN WT. 69,990

BUFFER CAR (5 CARS) WT. 250,000

IMPACT NO.	END STRUCK	VELOCITY (MPH)	REMARKS
1		4.24	No movement.
2	B	6.10	Strapping gate rebounded forward 3/16-inch at the gate's center.
3	B	Unknown	Both remaining bands failed through the crimp in the banding. FAILURE.





U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-89-692-4191. View of the failure of both of the 1 1/4-inch steel straps following the 8 mph rail impact. Note: The strap was not doubled across the strapping gate.